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THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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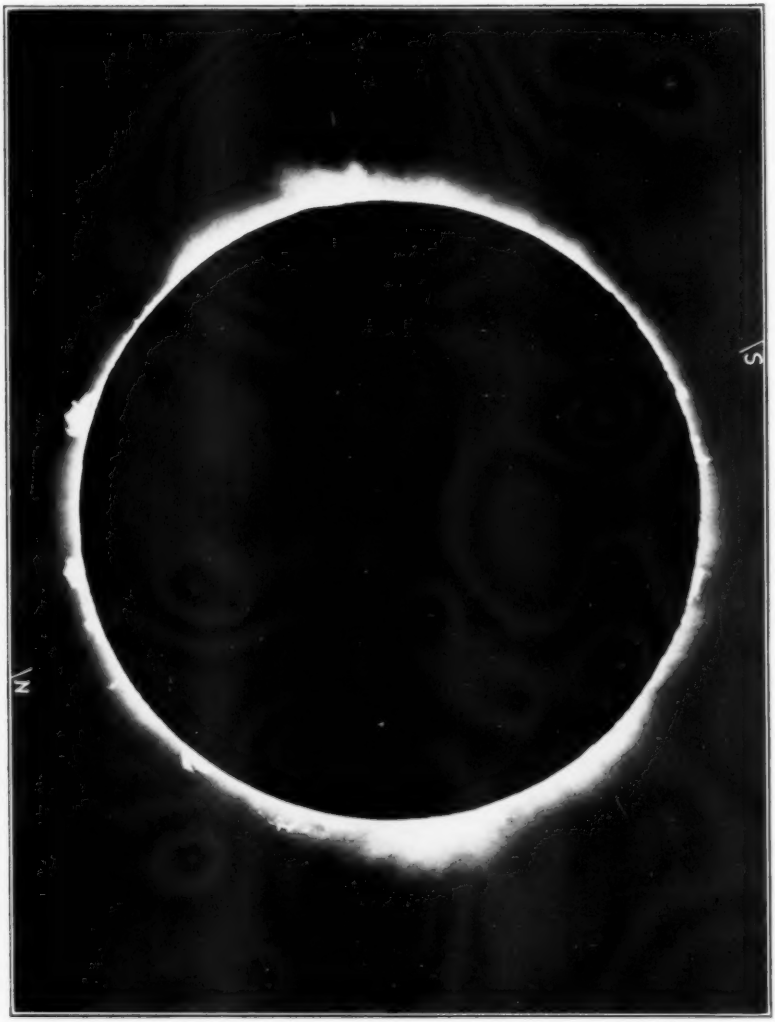

TOTAL ECLIPSE OF THE SUN, JUNE 29, 1927

Solar Corona photographed at Giggleswick by the Royal Observatory expedition. Exposure 19 sec. The letters N, S indicate the Sun's axis.

Journal of the Royal Astronomical Society of Canada, 1927

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VOL. XXI, No. 8, 9 NOVEMBER-DECEMBER, 1927 Whole No. 169

SOME ADVANCES DURING THE PAST YEAR IN ASTRONOMY AND ITS ALLIED SUBJECTS*

By A. F. HUNTER

The Council of this Society having authorized, at its meeting on April 29th last, the formation of a Toronto Centre, and having recommended that the new order of management should come into force at to-night's meeting, officers should be chosen for the management of the centre. Accordingly, some account of the Society's history and its past transformations will be necessary in view of these modifications in its internal business arrangements.

When "The Toronto Astronomical Society" in 1903 changed its name to that of "The Astronomical Society of Canada" and was granted permission to prefix the word "Royal" to the new name, the promoters of the change did not adopt the federal system as the basis for the reorganization. This was perhaps not necessary at that time, and would even have been anomalous as its affiliated branches were then located in places within easy access of Toronto, *viz.*, in Hamilton, Simcoe, Guelph, Meaford, etc., with all of which intercommunication between the centre and the branches was convenient. In course of time, however, these branches expired and new so-called centres arose in larger cities situated at greater distances from Toronto, where, from the larger populations, there could be greater vitality than the defunct branches had possessed. But, in these larger places at greater distances, there is less interest taken in the meetings of the Society at Toronto, and less disposition for co-operation with the maternal city of the Society, in the matter of holding public meetings. The adoption of a federal system for

*Inaugural Address by the President, October 18, 1927.

the Society had therefore become a pressing need, and the Council decided, as already stated, to authorize the formation of a Toronto Centre.

The Society lost by death this summer the Rev. W. T. B. Crombie, M.A., formerly of Kingsbury, Que., and late of Montreal. His death is particularly regrettable, as he was the real founder of the Montreal Centre in 1918, having done much travelling by railway from his home in Kingsbury to Montreal to establish the centre at the latter place.

The current year,— the jubilee of Canadian confederation, the celebration of which was marked by so much enthusiasm,—has contained many centenaries interesting to students of astronomy and the physical sciences. The bicentenary of the death of Sir Issac Newton in March received wide attention, and meetings fitly observed the important anniversary, one held at the University of Toronto, others at various places on this continent, not to mention those held in overseas countries. Several other outstanding centenaries. in connection with some of the foremost names in astronomy and the subjects allied to it, have been held. This is the centenary year of the death of Pierre Simon, Marquis de Laplace, (1749-1827), whose name will always be associated with that of Newton as the two men to whom the develompent of the mechanistic side of astronomy is due. Besides the names of Newton and Laplace, it is the centenary year of the death of Augustin Jean Fresnel (1788-1827), the French physicist who did so much to place the undulatory theory of light upon a substantial footing. It is also the centenary year of the death of Alessandro, Count Volta (1745-1827), whose name will always be remembered in connection with the electric current. It is the centenary year of the birth of Sir Sandford Fleming who did so much to promote the adoption of the system of time-belts on this continent. It is also the centennial of the founding of the University of Toronto, which that institution has been recently celebrating.

The completion of the Transactions of the International Mathematical Congress held at Toronto in 1924, is one of the local events worthy of mention as one of the outstanding advances. These Transactions contain numerous papers of an astronomical nature.

It has usually been one of the features of the opening meeting

of the term or year for the retiring president to give a review of some portion of the field of astronomy, and its allied subjects. The order followed in my address of last year was as suitable as any other, and so I will follow the same this year, *viz.*, to begin with the remoter objects, the nebulae and the stars, proceeding inward to the solar system, and then finally coming to the Earth itself.

The Nebulae and the Stars

Forty per cent. of the galactic novae have appeared in Sagittarius according to a recent estimate by Dr. Harlow Shapley. ("Science," Aug. 19, 1927). This constellation is almost diametrically opposite the place (in Lyra) toward which our sun and his system is moving. A preponderating number of novae have also appeared in the galactic constellations in the neighbourhood of the apex itself of the sun's way. While Dr. Shapley gives a different explanation of the first-mentioned crowding in Sagittarius, the foregoing facts afford some ground for believing that the novae, as optical phenomena, are results of the concentration of light made by the changing position of the sun and the solar system in space. And this view is strengthened by the fact that after the illumination, or the so-called explosion, of the star has passed off, is settles down and appears as it did before. Moreover, practically all stars of high luminosity,—Class O stars,—lie along the galactic circle. It would seem therefore that the illumination of stars depends upon the conditions under which we see them.

One of the consequences of Einstein's view requires that light coming from the surfaces of large masses like stars must have its spectrum lines displaced toward the red end, owing to the light having passed away from a strained, or gravitational, medium into one nominally free. A displacement of the spectrum lines, or Doppler effect, is inferred. But the result must again be qualified by the light being accelerated when it arrives in the vicinity of another large mass like our sun with its planetary system; there can therefore be a displacement in the spectrum lines of only the difference between the two influences. And still further, the displacement of spectrum lines in light from, and subject to the influence of, such immense aggregations of matter as the nebulae (including our own galaxy as an influence) must necessarily be very great. This was actually

found to be the case by Dr. Slipher from observation and confirmed by others, but it has been interpreted, with doubtful accuracy, as the rapid motion of the whole nebulae in the line of sight.

Our Planetary System

The close approach of the Pons-Winnecke comet to the Earth on June 27, and its visibility to the naked eye for a few nights about that time, aroused some popular interest.

In planetary studies, the perplexing question of the rotation of Venus has received some further attention during the year, the trend of belief based upon the observations being toward a period of about three days of our terrestrial day-lengths.

The 1926 opposition of Mars has yielded some results of interest, and astronomers are discussing their significance. It is not easy to reconcile some of them with known facts. For instance, at the surface of Mars, the intensity of the solar radiation is less than half of what it is at the surface of the Earth. We know this because the intensity of the sun's radiation varies inversely as the square of the distance. When the distances of the Earth and Mars from the sun are taken into consideration, the ratio of the radiation received from an overhead sun on a unit area of Mars (leaving possible differences of atmospheres out of account) would be to that upon a similar area on the surface of the Earth as 86:198. If the scale of absolute units of temperature be used, the heating power of the sun at Mars would make a difference of 160 degrees from that on the Earth's surface. And because of that planet being smaller than the Earth, its greater rotundity would further diminish the sun's heating power. Engaged as we are with the hard facts of science, it is evident that at a temperature of 150 degrees below the freezing point of water there could be little chance for plant and animal life on Mars, as we know on the surface of the Earth. Popular beliefs can easily take rise from the slender foundation of the optical colors seen on the Martian surface, and idle speculations regarding vegetation as we know it are not safe. But if we are receiving, from some cosmic source or sources other than the sun, as the trend of recent opinion seems to indicate, radiant energy in an electric form, or otherwise, which is finally converted into heat, and if the nominal temperature at the surface of Mars so nearly resem-

bles that of the Earth's surface, as the observers find, then our old ideas of the surface temperatures of the large outer planets may also have to be changed. In this particular we find the urgent need of more knowledge of cosmic electric forces.

There was widespread interest in the total solar eclipse visible on June 29 in Northwestern Europe. It is gratifying to learn that in some places the eclipse was observed with a measure of success.

THE ECLIPSE OF 1932.—In connection with this branch of solar studies, although the present time is still five years in advance of the next total solar eclipse visible in the accessible parts of Canada, *viz.*, on August 31, 1932, systematic examination of the areas in which the track of totality will lie, might well begin now with a view to the selection of the best eclipse stations as free as possible from unfavourable cloud conditions. Its duration will be about 2 minutes, or similar in length to that of January 24, 1925. There will be a total solar eclipse of some promise on May 9, 1929, with a long duration of about 5 minutes, but its path will be tropical and sub-tropical, crossing the Malay peninsula, Siam and the Phillipine Islands and altogether mainly across the Pacific Ocean. The cloud conditions, from its situation in the tropical and sub-tropical cloud-belts, will make success somewhat doubtful. If we neglect that of next January in the inaccessible Antarctic regions, the only other observable total solar eclipse, until that of 1932, *viz.*, that of October 21, 1930, will lie almost wholly in the Southern Pacific Ocean, and will furnish very few land localities for observation. Accordingly, the eclipse of 1932 gives better promise than that of any other until then, and the hopeful prospect of success makes it necessary to begin to look ahead and to employ the intervening time to some advantage. It is a return, in the course of the Saros or 18-year cycle of eclipses, of the important eclipse of August 9, 1842, from which dates the beginning of modern eclipse investigation. In this series were the great eclipses of 1860, 1878, 1896 and 1914. As the fractional part of a day in the Saros makes every return of that eclipse fall about 120° of longitude farther west than the last occurrence, the third return always takes place near the same region of the globe as it did 54 years before. The eclipse path of 1878 crossed Pike's Peak in the Rocky Mountains and Manitoba. In the 54 years that will have elapsed by 1932, this return of the eclipse of

1878 has undergone some change in latitude and direction, but only a minor change in longitude. A revised computation of part of the path of totality appeared in the *Journal* of November, 1925. Its path will lie mainly across the Province of Quebec for 700 miles, and being a summer eclipse, many portions of the path will be quite accessible. Cloud observations can be collected for the months of August and September, during the ensuing years, at all the available parts of the totality belt, to determine the stations that will be likely to have the best weather at that time of the year. The Central Meteorological Observatory, Tokyo, Japan, collected cloud observations during July and August for three years prior to the eclipse of August 9, 1896, in Japan, and issued a pamphlet on the subject. The U.S. Weather Bureau made investigations of the cloud conditions of the eclipse belt across the southern states on May 28, 1900, the data covering the years 1897, 1898 and 1899; a Bulletin on the subject was issued in 1899. Similar preparations have been made in other countries for other eclipses of modern times. As the one of 1932 will be chiefly in Canada, (700 miles), preparations might well begin now. Transient disturbances of weather at the time, as created by a passing cyclone or area of depression, might of course be unfavourable to the chances on the day of the eclipse. But these could be anticipated for a few days in advance.

The Earth Itself

As the next sunspot maximum again draws nearer, there are increases in extremes of terrestrial phenomena,—more frequent auroras, cyclones and anti-cyclones numerically more abundant, and wider barometer readings.

The occurrence of several earthquake shocks of extreme magnitude and volcanic eruptions have stimulated studies of the Earth itself. An earthquake of unusual violence occurred in the Province of Kansu, China, on May 22, in which 100,000 persons perished. Another occurred in Palestine on July 11, causing serious damage and loss of life.

The crater of the Kilauea volcano, Hawaiian Islands, began an eruption on July 7, after a silence of many years, and the Hale-

maumau pit, 8 miles wide,—the largest crater in the world,—continued in eruption for several weeks.

There was intense activity on August 23, of the volcanic peak of Bogoslof Island in the Western Aleutian Islands. (This volcano rose from the bed of the ocean on May 18, 1796). Investigators reported twenty volcanoes in action in these islands about the same time as Bogoslof.

In the series of papers and addresses given at the Toronto meetings of the Society in the past session, there was one of unusual value for the outlook it furnishes in meteorological science, *viz.*, that by Sir Frederic Stupart on February 15, on "Northern Anti-cyclones." That it is usual for a class of anti-cyclones to take their rise in an arctic or sub-arctic quarter, especially in the Mackenzie River basin or beyond it, just as a series of cyclones originate at parts of the tropics, is a truth the development of which forecasts a general law, and the importance of which is considerable. The two classes,—cyclones and anti-cyclones,—and their origins in opposite zones of the globe, one in the tropics the other in the arctics, seem to be analogous to the sunspots, and the consequences of Sir F. Stupart's observations are therefore important.

In another article, one in the *Journal* of November-December last, Professor Howard T. Barnes of McGill University, Montreal, mentioned that he had accomplished the photography of the colours of sunrise with colour plates. He was assisted by Mr. Walter A. Connolly. The results of their work (some of which are shown at this meeting) are interesting and mark it as one of the outstanding advances in the last year.

The improvement of astronomical observations, to be used in making permanent records, is always much needed; and to effect this improvement it is always advisable to adopt the plan of working in groups, as in this Society and its branches or centres. For this reason my aim in giving these notices of scientific advances has been to make a review of some outstanding observations of the past year and the different fields in which the work has been done. As Astronomy was the first of the sciences, and is still the most useful and the most important of them, having brought about the development of the physical sciences, it deserves the foremost place in whatever can be done by public effort and co-operation.

THE TOTAL ECLIPSE OF JUNE 29, 1927

AS SEEN BY A SPECTATOR AT SOUTHPORT, ENGLAND

By Sylvia Seeley

The total eclipse of June 29th has been amply dealt with both from the technical and spectacular point of view. But unfortunately, partly owing to the relatively small area in which totality was visible, partly owing to adverse weather conditions, the number of those privileged to get a fair view of the eclipse either in England or Norway, was very limited. As one of those who had the great fortune to be included in that privilege, I have ventured to put these few words together as a mere spectator's tribute to one of the most appealing phenomena that one can see on this earth.

The shadow of the moon, in the words of Dr. E. H. Rayner, "a slightly conical cylinder about 240,000 miles long," first touched land at Cardigan Bay 5h. 23m. G.M.T. The narrow belt of totality, only about 28 miles wide, swept across England in a line to include parts of North Wales, Lancashire and Yorkshire. Thousands upon thousands of spectators were gathered at various centres in the line of totality, from one side of England to the other, only to be greeted on the great day with a drenching and hopeless dawn of impenetrable clouds.

On the other hand, if the acme of good fortune was reached by the Greenwich Observatory Camp at Giggleswick, one or two other places, such as Blackburn and Southport, shared that good fortune to a less degree.

Southport lies on the Lancashire coast about twelve miles north of Liverpool, one of the wettest and mistiest areas in all England. But it was on the very centre line of the totality belt. About 4 a.m., on the morning of June 29th some quarter of a million people (including the writer) were tramping towards the sand hills along the Southport shore. Dawn was inexpressibly grey and dreary, typically English and ominously suggesting something of that stupendous and nerve racking strain that must be the fate of all those officially

observing, when the feelings of mere spectators, with no part to play, were keyed up to such a pitch of anxiety. What a tribute to human achievement are those complete records produced by official parties at so many eclipses, in conditions of unparalleled tensity when all must be accomplished to perfection within the compass of a few precious moments.

It is interesting to note that Professor S. A. Mitchell, writing in 1925, says of the 1927 eclipse:—"Liverpool is in the eclipse track, but totality occurs at 5.24 in the morning, and lasts only 24 seconds, with the chances of clear weather almost nil;" and later he says:—"It is certain that no great astronomical discoveries will be made at the 1927 eclipse with such a brief interval to carry on observations and with a great probability of clouds."[1] That great probability of clouds revealed itself as a great certainty on the morning of the eclipse, and as the ever growing throng of spectators perched themselves on the various vantage points which the sand dunes afforded, they became sadly damped both in spirit and flesh.

About 4.30 there was a suggestion of sunlight and a faint pink glow in the east. Thereafter hopes and fears alternated with an uncomfortable predominance of the latter. Presently, however, as the sun rose higher he became a little more self assertive, until at last an appearance of flattening was observed on the right side of the sun's disc. This was the signal for a curious silence that seemed to fall over everything and grew ever deeper with the deepening shadows. Then followed some moments of keenest anxiety while the sun, yellow and watery, vanished and reappeared and vanished again with agonizing uncertainty, specially as at each appearance, less and less of the sun's disc was visible. Hopes receded into the gathering black shadows of the west. At 5.15 light clouds were still hovering about, and the strain of anxiety seemed to become almost unbearable. At 5.20 nothing was left of the sun but a delicate sliver of orange light to illumine the supernatural gloom all around. Then at 5.24, with awful suddeness, the glory of those 23 immortal seconds burst upon us. Low in the eastern sky hung the black disc, black indeed, yet suggesting something translucent and spherical.

[1] "The recent total eclipse of the Sun" (pub. 1926) p. 20.

Surrounding this the corona showed like a halo, very regular in shape, and the colour of pink hydrangeas when they are fading to blue, iridescent with a mother of pearl texture fading into a tender silver light.

The solar prominences were subdued by the misty atmosphere to a delicate rose colour, and, though certainly visible, were not as conspicuous as clearer weather conditions would have allowed. In this respect Southport certainly did not share in what the Astronomer Royal so happily termed "The luck of Giggleswick." The most noticeable prominence appeared to rise from the uppermost rim of the disc, and was estimated by Professor D. W. Morehouse (also at Southport) to be an eruption fifty thousand miles in height. A second prominence, whose appearance, unlike the first, had not been anticipated was dimly discernible on the left, and just opposite to it on the right side was the mere suggestion of a third one. But the outstanding feature of the moment was undoubtedly one of colour, the very faint pearly-pink chromosphere, shading into the silvery mauve corona, beyond all human art to represent, beyond all human words to describe.

The sense of exaltation produced by such stupendous beauty was so great that when the first pencil of light from the reappearing sun robbed the corona from our eyes, one seemed to fall back to earth through an untold distance, back to the common reality of ourselves, our fellow beings, and the wet sand on which we stood. Totality was ended.

It was significant that although the eclipse was still at a very striking stage and the black gloom in the west still very awe inspiring, no one seemed to care to watch the uncovering of the sun's face. Indeed, it was then we began to realize by how narrow a margin our good fortune had been won. About 5.40 a.m., a soft fine rain began to fall, and long before the eclipse was ended, the sun was entirely obscured by clouds.

I may perhaps here again quote the words of Professor S. A. Mitchell regarding the 1925 eclipse, as they are equally applicable to 1927. "As a spectacle," he says, "the 1925 eclipse suffered from its taking place so early in the morning. If the darkening had come on during the middle of the day with the sun high up in the sky,

the psychological effect would have been all the greater. Still it was a gorgeous sight."[1]

Profesor H. H. Turner, who in collaboration with Dr. Knox-Shaw was directing the Oxford University and Radcliffe Observatory Expeditions at Southport said that considering what might have been, we had had extraordinarily good luck. Though the sun was obscured just before and soon after totality, he said that they had obtained what was, under the conditions, a very satisfactory view of the corona and prominences. But those conditions were not sufficiently favourable for carrying out the most important part of the Oxford party's programme—an endeavour to find out whether the light of the corona was polarised, how far it was reflected from such matter as dust particles, and how far it was self-luminous. In fact Southport, unlike Giggleswick, was only a spectacular, and not an astronomical success. But the other official parties, had not even so much luck as Southport. At Richmond, in Yorkshire, the site selected by the Norman Lockyer Observatory party, the conditions looked, according to the official report of the Director, Dr. W. J. S. Lockyer, "entirely hopeless, and continued so until well after half of the second series of partial phases had elapsed, and even then for only a few minutes was the sun seen. In accordance with the instrumental programme and the megaphone time signals, the whole routine work of the Camp was gone through at the total phase, but of course with no successful results."

At Stonyhurst College, although a view of the corona was obtained by those furthest from the Observatory, the work of the Director, Father O'Connor, was completely hindered by clouds which obscured the sun till one minute after totality was ended.

Owing to the short duration of the eclipse and the general chilliness of the morning any remarkable drop in temperature was not perceptible at Southport, nor were any official temperature records taken at Giggleswick. One unofficial observer said he had recorded a drop of 10° F.; but the Astronomer Royal said that though the drop was perceptible, he doubted if it were more than five or six degrees. It was thought that totality had begun three seconds

[1] "The recent total eclipse of the Sun," p. 14 (1926).

earlier than predicted, but that was a provisional error as the exact position of the Greenwich Observatory Camp had not been worked out. The duration of totality was, however, in precise accordance with prediction.

So passed those memorable 23 seconds, or to be more accurate according to Dr. L. J. Comrie, 22.8 seconds, a landmark forever in the lives of those privileged for the first time to see the Sun's Corona, whose secrets are only revealed to us for some few minutes in each century.

Elgin Annex,
Ottawa, 1927.

PROGRESS OF METEOROLOGY SINCE CONFEDERATION*

By J. Patterson

The history of Meteorology may be divided into three periods. The first, which ended about 1650, made no advance since the time of Aristotle and was limited to what is called "weather lore," derived very largely from astrology.

The second period began with the discovery of the barometer in 1643 and was thus the beginning of the real study of the physics of the atmosphere. It seems that very soon after the discovery of the barometer, weather changes were associated with it,—hence the name "weather glass,"—and it was about this time that the weather conditions given on the dials of household barometers first appeared.

This period lasted over 200 years until the production of the Weather Map in the sixties ushered in the third and present era of meteorological endeavor, which is thus contemporaneous with confederation.

The introduction of the Weather Map and the discovery of the development and movements of storms created a very great enthusiasm for the sutdy of the weather and led to the establishment of Meteorological Services in most of the countries of the world. It is interesting in this connection that the present Director, Sir Frederic Stupart, has been connected with the Canadian Service since its inception, and has had a very large part in developing it to its present position. The weather, however, knows no international boundary, and no sooner were the Services in the various countries established than an international organization was formed to obtain uniformity in observations and to further the progress of meteorology.

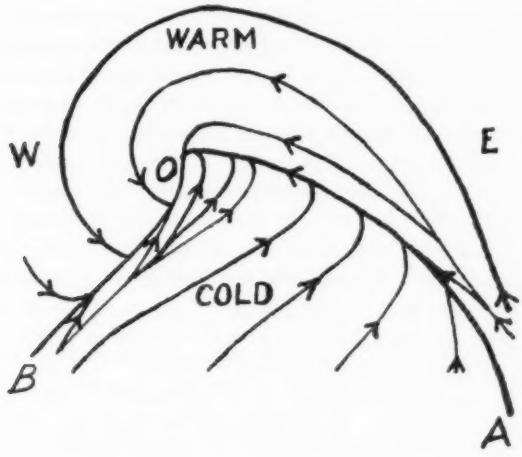
*Address delivered before Section III of The Royal Society of Canada at the meeting in Ottawa in May 1927.

During the first half of our period the meteorologists were engaged in extending the area over which observations could be taken on land and also at sea, and building up a theory of the structure of the atmosphere from surface observations. Some balloon ascents were made, but they were too few to add any material knowledge to that furnished by surface observations.

The first use that was made of weather maps was to warn shipping of the approach of storms, and this has been one of its important functions,—especially important in the regions where tropical cyclones occur. With the development of forecasts the demand for forecasts for other purposes has steadily increased. In Canada besides shipping, the railways receive storm warnings, the fruit growers for weather conditions that affect spraying and early and late frosts; the merchants for shipping fruits and perishable goods, the aviators for flying and the foresters for dangerous forest fire conditions. The importance and value of the weather information that can be supplied for the benefit of man is ever widening and becoming a more and more important factor in the economic life of the world.

The Norwegians are at present developing a new method of attack on the problem of forecasting. They regard the weather in the northern hemisphere as largely dependent upon the existence of a surface of discontinuity between polar and equatorial air. The polar air is cold, dry, and transparent and moving from some easterly point, while the equatorial air is warm, moist with poor visibility and moving from some western point. Thus in the accompanying illustration the equatorial current meets the cold current sideways along *OA* and climbs up over it, thus producing heavy rain, while the cold air bends round in a southerly direction to the west of the warm air, and undercuts it along *OB,* thus giving rain in a narrow band. This method is giving very good results to the Norwegians but it has not been so successful in other countries that have tried it.

It may be well to note here the advance that was made by the introduction of the Weather Map. Previous to this, the barometer and most of the other meteorological instruments were in use at various stations, but these were not co-ordinated and consequently acted as individual units. From the observations, especially those



of the barometer, and from a study of the sky, a person in time can become a forecaster in his locality for a few hours in advance, or longer during settled periods. Weather maps extended this area enormously, until now they cover a large part of the land areas of the globe and part of the oceans. The forecaster by studying the signs and changes indicated on these maps, predicts the weather 24 to 36 hours in advance, or at times even longer, but the two methods are essentially the same, and neither attempts to deal with the fundamental principle—the cause of these changes. This still remains unsolved.

The Weather Map gives only surface observations and is thus two-dimensional, but the weather is three-dimensional and consequently the atmosphere must be studied throughout its length, breadth and height if we are ever going to understand it, and herein is the apparent difference between the methods that have to be adopted in this investigation to that in physics. In the latter instruments are constructed and methods devised for making the experiment, but only sufficient observations are taken to interpret the results; the meteorologist on the other hand appears to be engaged chiefly in collecting observations, and no doubt to the physicist he seems to

be wasting his time, but in reality he is following the only method by which it will ever be possible to solve the problem of the weather. After all, when it is considered that the physicist performs his experiments within the narrow confines of a laboratory while the meteorologist must make his observations on the world-wide processes that are taking place in the atmosphere, it will be realized that the two methods are essentially the same. The real problem before the meteorologist is the obtaining of enough observations throughout the atmosphere that will disclose sufficient evidence of the general circulation of the atmosphere and its variations to enable him to obtain a mental picture of the problem of the atmosphere in the same way that Kepler's co-ordination made it possible to form a mental picture of the solar system.

The indispensable foundations of knowledge of the atmospheric system are:—radiation; the distribution of land and sea; the distribution of pressure, temperature and water vapour. Any hypothetical arangement that ignores one or other or all of these fundamental conditions may be a most instructive exercise, but it is not strictly speaking, meteorology.

To advance then, it was necessary to take up the exploration of the atmosphere. Meteorologists had long recognized this as an investigation of the greatest importance, but it was not until instruments and methods had been developed, in the later part of the nineties, that it was possible to embark on this great venture; and from that time, balloons have been sent a-voyaging into this unexplored region and bringing back a rich harvest of material. Out of this harvest we have discovered that the temperature does not go on decreasing to absolute zero with increasing height in the atmosphere, but that at only a moderate elevation, from 6 to 12 miles above sea level, the temperature suddenly ceases to fall and actually rises slightly with increasing elevation, up to the highest points reached by balloons This region of fairly constant temperature with height is now called the "stratosphere" in distinction to the lower region, the "troposphere." The level where the change occurs is called the tropopause," and the height and temperature of it is higher and colder at the equator than at the poles. The tropopause is the upper limit at which clouds can exist.

The structure of the atmosphere, with respect to temperature in the cyclone and anticyclone as derived from the surface observations without any knowledge of the upper air, indicated that in a cyclone the centre was warm and in the anticyclone cold, but upper air observations have revealed that the reverse is true, that the air in the core of a cyclone is cold and in the anticyclone warm.

From the results of the balloon observations, Sir Napier Shaw has devised a diagram, similar to an indicator diagram for a steam engine, by plotting the absolute temperature t against what is called potential temperature T derived from the equation

$$\text{Log } T = \text{Log } t - .286 \ (\log p - \log p_0)$$

where p is the pressure at the place and p_0 a standard pressure. From the diagram so obtained it is possible to tell whether the weather conditions are stable or unstable. Could this information be made available in time for forecasting, it would be of very great assistance.

These investigations of the upper atmosphere are pointing the way to a solution of the problem, but at the same time it brings meteorology again to the parting of the ways, either it must be content to achieve what success is possible by present methods or advance boldly to a real knowledge of the structure of the atmosphere and its changes so that not only the whole sequence may be expressed but the physical processes may likewise be explored. Then we may really understand the weather.

Meteorological Office,
Toronto.

THE TILDEN METEOR, AN ILLINOIS DAYLIGHT FALL

By Charles Clayton Wylie in *Science*

On the afternoon of July 13, 1927, at about 1:00 P.M., central standard time, a stony meteor, hereafter referred to as the Tilden meteor, fell near Tilden, Illinois, about forty-five miles southeast of St. Louis, Missouri. The meteor fell in an area roughly two by seven miles, and four stones have been recovered, three of which weigh, respectively, one hundred and ten, forty-six, and nine pounds. The fourth is a small piece weighing a fraction of a pound.

The meteor came from the southeast, its path being inclined at an angle of perhaps fifty degrees to the horizontal, and with a velocity equal to, or slightly in excess of, the parabolic. Its brilliancy was such that at a distance of more than a hundred miles it appeared as "a piece falling off the sun." At a height of fifteen or twenty miles it burst, showing green and then purple, and after a second bursting, was invisible to persons at a distance. A cloud of smoke was visible near the point of fall, but the falling pieces quickly had their velocity reduced so that they were no longer luminous by daylight, and only one piece was actually seen while falling. It was seen as "a dark streak, like smoke, for an instant."

The sky was partly cloudy in the vicinity of the fall, so few there saw anything, although nearly every one was looking, after the house-shaking blasts of the detonations. Following the detonations a roar like a tornado, or an earthquake, rolled to the southeast and died away in the distance. The meteor travelled with a velocity greater than that of sound, so the roar from the more distant portions of the path was heard after the detonations of the bursting in the nearer portion. This helped in evaluating the stories of the few who saw anything, for every one heard the sound rolling toward the southeast and assumed the meteor was travelling in that direction. The stones were actually seen to fall, and the smoke to roll, in the opposite direction.

The falling stones made a hum like an airplane flying high. The two larger stones could both be heard over considerable territory and at one place five men were out in the group straining their eyes to see an aviator who "flew over and passed out of hearing in the northwest, then came back flying much lower and landed a little to the north of the group."

The three larger pieces were heard to strike, the largest a few seconds after the blasts, the forty-six-pound piece "perhaps three minutes after," and for the nine-pound piece we have two careful estimates, "three to five minutes" and "five to eight minutes." The fact that for even the largest stone the thud of striking the earth was heard after the detonations of the bursting meteor shows that the average velocity of the fall from the point of bursting to the earth must have been less than the velocity of sound. Since the velocity of this meteor was twenty-five to thirty miles per second in the upper atmosphere, and sound travels at the comparatively leisurely rate of a mile in some five seconds, we have a striking illustration of the tremendous resistance of the lower atmosphere to bodies travelling at high velocities.

The soil of the territory is rather a stiff clay, and it was very hard because of no rain for weeks. The largest piece struck on the edge of a field of cow-peas, and went down three feet ten inches. The forty-six-pound piece went down fifteen inches in a clover pasture. The nine-pound piece went down five inches in grass in a back yard, and the small piece was found lying on a lawn. The fall was nearly vertical at the last, the largest stone departing about six inches from the vertical in penetrating three feet ten inches. The impact in no case noticeably scattered the soil; the holes were simply driven into the ground. The nine-pound stone was easily lifted out of the hole. For the forty-six-pound piece a little digging with a pocket knife was necessary; and the removal of the one hundred and ten-pound stone required two hours' hard work for two men with spade, pick and crowbar. It was wedged "as if it were set in concrete."

The meteorites are composed of a light gray stone, and show small silvery globular aggregates, presumably of nickel-iron. The surfaces show typical pittings and a typical black crust, being blackened and pitted in fairly uniform fashion. From a preliminary

study of the literature available, this fall apears to be the first recorded from the state of Illinois, and the one hundred and ten-pound stone ranks among the largest seen to fall and preserved reasonably intact. Plaster casts will be made of the larger stones of this fall.

It should be said that the information in this note was obtained by personal interview, the writer visiting people, not only in the vicinity of the fall, but more than a hundred miles from that point. University of Iowa.

A Beautiful Sonnet

In a recent number of *Science* was a sketch and appreciation of the life of Edwin F. Smith, a distinguished plant pathologist of the U.S. Department of Agriculture who died on April 6, 1927. In addition he was a gifted poet, and one of his sonnets fittingly closes the account of his work:—

Quietude: A Prayer

God of all flesh, when these my days are sped
Let me but hear the music of the spheres
Or see, far off, the progress of the years
And I shall be greatwhile content though dead;
For to their heavenly music I am wed
And thrill with subtile thrills, nor yield to fears.
Thy great To-morrow wipes away all tears
And there, as here, Thy law shall be our bread.

Then let me dwell in some great quiet place
Where I may brood in peace on time's deep things
And all the mystery that round man clings;
Far off, mayhap, have glimpse of one sweet face;
And catch the tones of twanging golden strings
Whereto Thy myriad million stars keep pace!

VARIABILITY OF THE ROTATION OF THE EARTH[1]

By R. T. A. Innes

The common needs of mankind in all ages have fixed the day as the unit of time; that is one rotation of the earth upon its axis, with regard to the sun. A more scientific choice would be the rotation with reference to the stellar system, but the alterations of light and darkness force the solar and not the sidereal day upon us. Fortunately the reduction from the mean solar day to the sidereal day is known with great precision. The choice of a day as our unit of time is a good one, because it is so nearly invariable that only the most refined observations combined with almost perfect dynamical theories can detect the change in speed of rotation. In fact invariability is so nearly realized that neither observation nor theory previous to about 1860 could detect any trace of change in the length of the day.

All earthly time-keepers such as clocks and chronometers are quite useless as checks upon the rotation of the earth. Kelvin suggested the time of vibration of a spiral spring but this and other proposed methods are merely fanciful. The only checks on the rotation of the earth are supplied by the movements of the heavenly bodies. If for the moment we suppose that the moon moves uniformly around the earth then it would give a partial check; partial because it might happen that both the motion of the moon and the rotation of the earth were varying in such a way that a point-to-point correspondence was maintained. But the moon is too closely connected with the earth to let us ever be quite sure of independence. If instead of the moon we made the same assumptions for

[1]This article appeared in the August number of the well-known international magazine "Scientia." English agents: Williams and Norgate, London. —Editor.

say a satellite of Jupiter, the test would be more telling. Or if we take the two motions and compare them with the earth's rotation, and all preserved a point-to-point correspondence, all would be straightforward.

Theoretically we are not limited to the moon and one satellite of Jupiter. We could make use of the motion of the distant planet Neptune, or even compare the periods of variable stars. The motion of Neptune is far too slow and therefore too coarse to check so fine a time-keeper as is our earth. The periods of the variable stars are never very well-known and they all seem to be subject to inequalities arising from causes quite unknown to us. The satellites of Saturn and the other planets are too difficult to observe, although if the earth's motion had a constant acceleration, that is a variability involving the square of the time elapsed, it would ultimately be disclosed by their motions.

There is however another check available. Transits of Mercury can be observed with considerable accuracy and the theory of the motion of this planet is sufficiently simple and so well-made that the times of contact of Mercury with the sun's edge can be used for the purpose.

If we take these methods of finding time in their order of usefulness, we might say that the motion of the moon provides the most convenient test. The next is the motion of Jupiter's Satellite I of which the oft-recurring eclipses can be observed with an error of at most a few seconds of time. Then follow the somewhat rare transits of Mercury which happen about thirteen times in a century.

These would seem to be by far the best tests by which the rotation of the earth can be checked if it does not vary from a mean by more than about plus or minus 20 seconds.

If the deviation from the mean begins to exceed 20 seconds then it will be reflected in the coarser movements of the sun and the planet Venus, to which might be added Mars when in opposition.

Previously to Brown's, the only passably complete theory of the moon's motion was that due to Hansen, but soon after Hansen's tables came into use in 1862, it was seen that they did not accurately represent the moon's place. Newcomb made valiant attempts to revise and patch up Hansen's tables, and made extended comparisons

with observations, ancient and modern. In his last paper, he gave the fluctuations of the moon's calculated position and remarked:

"I regard these fluctuations as the most enigmatical phenomenon presented by the celestial motions, being so difficult to account for by the action of any known causes, that we cannot but suspect them to arise from some action in nature hitherto unknown. A brief résumé of possible causes, and the difficulties in accepting them, may be attempted. Taking it for granted that the gravitation of all known bodies has been allowed for in the comparison, and that no unknown bodies exist, the first explanation to occur to us is that the inequalities are only apparent, being perhaps due to fluctuations in the earth's speed of rotation, and therefore in our measure of time. I suggested this explanation in my earlier papers on the subject. It is open to the objection that it seems scarcely possible to account for changes so large as would be required through the action of known causes. But the explanation admits of an independent test from observation. If the fault is with our measure of time, it can be detected by the transits of Mercury and by the eclipses of the first satellite of Jupiter."

Brown's tables of the moon's motion are founded on the best observational material, and as far as can be judged on an exhaustive gravitational theory. More than 1,000 separate perturbations due to gravitational forces are included in his tables. Yet so as to predict the moon's motion as closely as possible he was forced to include empirical terms. His tables came into use in 1923, but already fail to represent precisely enough the moon's longitude.

The theory of the motion of Jupiter's Satellite I is curious and interesting because of its great inequality, but it may be considered well-known so that it is not much exaggeration to say that its motion from eclipse to eclipse is the most purely harmonic in the solar system. Its motion is free from long period and secular inequalities. It is therefore an excellent check. Newcomb had intended to work up all the observed eclipses but his work was incomplete at his death and still is. To a lesser extent these remarks may be applied to Jupiter's Satellite II; the remaining satellites of that or any other planet offer far less favourable conditions.

The remaining test is in the Transits of Mercury, and their usefulness in this connection as we see did not escape Newcomb. He reduced very fully all the observed transits from 1677 to 1881 and less completely others to 1907. Unfortunately the tables he had to rely on were Le Verrier's, certainly good but capable of improvement, being now more than half-a-century old. I have reduced all these transits, including that of 1924, using the latest tables, Newcomb's own.

When the tabular errors of these transits are plotted and are compared with Newcomb's curve of the moon's fluctuations, the similarity of the curves is at once apparent. It would be interesting to be able to add to these two curves, the curve for Jupiter's Satellite I from 1680 to date showing the deviations from the latest tables, Sampson's, but the work involved would occupy several years at least.

Fortunately a comparison is available for the last 16 years as the eclipses of both this satellite and Jupiter II have been assiduously observed under the same conditions during that period at the Union Observatory.

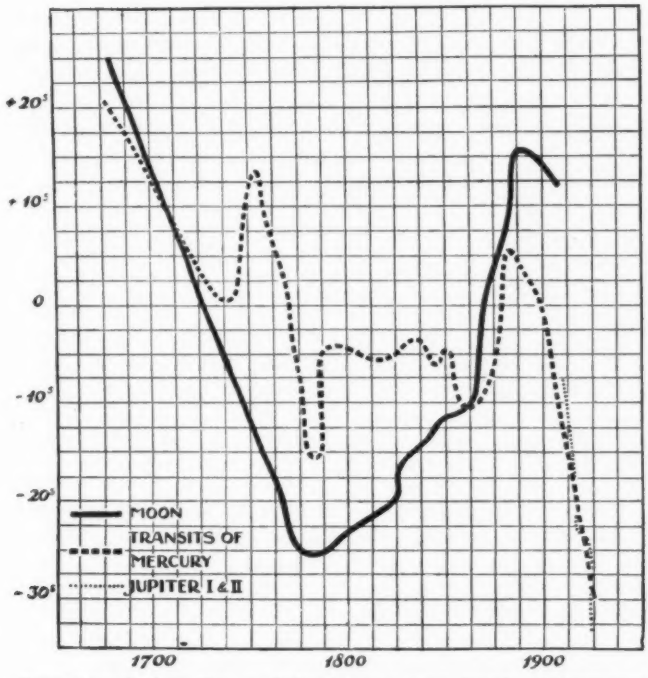
The clearest way to exhibit the correspondence is to reproduce the three curves.

The rather large divergences between the two curves about 1720-1770 and about 1800-1820 may be mainly due to the poor observational material available for those periods. The divergences may be real but are more likely to be accidental.

It will be seen that the correspondence is not exact. The essential features are however quite clear. About 1890 the earth's period of rotation suddenly decreased by about 1 second and the new period has persisted almost unchanged to this day. This change is confirmed by the three independent checks.

Newcomb's suspicion that the moon's fluctuations might be due to a change in the length of the day are thus greatly strengthened but not made certain.

A consideration of the general trend of the curves shown on the diagram points strongly to a continuous lengthening of the period of the day, interrupted by irregular variations. In the 220



Fluctuations of Mean Time as disclosed by the Moon, Transits of Mercury and Eclipses of Jupiter's Satillites I and II.

years 1700 to 1920, the earth slowed and lost on the whole 44 seconds of time.

Algebraically this gives, adopting 1810 as our starting point:

Length of Day in . . . $1810+t=86400$ secs $+ 0.004$ secs $(t-1810)$

Time elapsed since 1810 = Days of 86400 secs $+ 0.002$ secs $(t-1810)^2$

In other words the length of the day increases 1 second in 250 years.

But these figures must be taken with many reservations. The great recovery of 42 seconds between 1780 and 1880 might well be followed by another starting now. The future will show.

Can the earth's period of rotation change without affecting the intrinsic mean motion of the moon? Probably not, yet the connec-

tion may be obscure. If the correspondence is complete, then it would be sufficient to check the earth's time by lunar observations—preferably by means of the occultations of stars. The number of these which could be obtained at the time of first quarter in each lunation at a few observatories should furnish earth-moon time within 1 second. At intervals this time could be checked against the flow of time as given by Jupiter's Satellite I and more occasionally by the transits of Mercury.

In general, astronomical tables have been based on about a century of observation. The little diagram above shows that such a century might deviate by anything from 20 to 60 seconds of time from a mean century if indeed such a thing as a mean century exists.

This uncertainty in the true length of a century—or if preferred—in the length of our unit of time, makes it quite illusory to correlate very old observations, such as the historic eclipses, with present-day observations. The identification of these eclipses has always been dubious and in view of the variability of the measure of time used attempts to make use of them must be fallacious. Thus the celebrated secular variation of the moon deduced from such old eclipses is quite valueless. We cannot tell whether the secular change of the earth's rotation is positive or negative. Tidal effects would probably increase the length of the day, but the cooling of the earth would shorten it.

The diagram indicates that the length of the day alters by about 2 seconds from slow to fast or vice-versa rather suddenly, nevertheless the change might occupy five years. Even so the force required to effect this would be very large.

Previous to 1860 such a small variability could not have been found. Newcomb was the first to look for it systematically.

Glauert in 1915 by comparing the lunar fluctuations with those of the Sun, Mercury and Venus stated that it appears that the errors in longitude of the moon, the sun, Mercury and Venus may be accounted for by rather irregular variation in the rate of the rotation of the Earth, the changed momentum being partially or entirely compensated for by a corresponding change in the mean motion of the moon.

Brown, with much hesitation, is inclined to attribute the fluctu-

ations in the motions of the moon and planets to changes in the directions of assumed magnetic fields. He points out that we know that the earth's magnetic field varies and that the sun has such a field and that there is no inherent improbability in attributing similar fields to the moon and planets. The effect would be as though some kind of surge spread through the solar system and affected the planets and satellites the same way but in different degrees.

Eddington puts the position in this way:—That there are irregularities in the motions of the heavenly bodies, noticed particularly in the swift moving moon but shown also in a smaller scale in the sun and planets which appear to indicate that our standard timekeeper, the earth, is a little irregular, and he remarks that it is the rotation of the surface of the earth which determines our time; he finds it difficult to believe that there are irregular variations in the angular velocity of the earth as a whole but that it seems less difficult if the variations are merely superficial, due to the crust sliding non-uniformly on the interior; he suggests the idea that the motions of the magnetic poles might be due to this slipping, the magnetism being constant in the interior, but with the axis emerging at changing points of the crust as the crust slips over the inner magnet but, he remarks, so little is known about the motion of the magnetic poles that it is impossible to say whether they support this idea or not.

Other hypotheses may be found and it might be difficult to ascertain which is the correct one. The fact of the variability in the length of the day makes for simplicity. It will coordinate several lines of observation.

Fortunately, for the last forty years the change from the meantime of the previous century has been large and it is this that has made its discovery now easy and decisive.

Unless the cause of the variability can be found intuitively it would appear that centuries will have to elapse before the law of its change can be found.

In the meantime, the best thing that can be done is to find out from as long a period of observations as can be safely used, a mean length of the day and to ascertain the error of the resulting time from month to month as already mentioned.[2]

[2]The observational proofs of the variability of the rotation of the earth which appeared in the "Astronomische Nachrichten" some time ago permit some additions to this article.

As pointed out above, when the deviation exceeds 20 secs of time, the variability should be reflected in the motions of the sun, Venus and even Mars; this has been investigated by Spencer Jones whose conclusion reads:

"During the period 1836 to 1924 the longitude fluctuations of the sun, Mercury, Venus and Mars and also the minor longitude fluctuations of the moon, can be attributed, within the limits of the errors of observations, to changes in the rotation of the earth."

Brown, to whom we owe the current tables of the moon, has reconsidered the evidence and would now abandon "empirical" terms in favour of an irregular roation of the earth which might be due to expansions and contractions throughout its volume. Jeffreys considers this hypothesis but prefers superficial changes such as might be caused by fluctuations in the thickness of the polar ice-sheets and the consequent changes in sea-level.

On the contrary Fotheringham would ascribe everything to a motion of the earth's poles which he calls "trepidation" but this also requires that the mass of Venus should be variable and he has to exclude the striking evidence given by Jupiter's Satellites I and II.

De Sitter finds that Jupiter's Satellites, I, II, and III all confirm the recent change but in a magnified form.

So far all the evidence has been drawn from the solar-system. Le Roy has attempted, and with some success, to correlate the irregularities in the periods of variable stars. If this could be done convincingly, and it does not seem impossible, the proof would be acceptable.

Johannesburg (South Africa),
Union Observatory.

THE PLANET URANUS

A CONCISE TABULATION OF MANY ITEMS OF INTEREST TO THE AMATEUR

By W. G. Colgrove

Name—This was the first planet discovered; the others, excepting Neptune, having been known to man for many centuries. In 1781 Sir Wm. Herschel found it and called it Georgium Sidus in honour of the king. Later, however, at the suggestion of Bode, the present name was given as being more in keeping with the mythological names already borne by the other planets. It means Heaven or Sky.

Myth—Uranus was the husband of Gaea, the Earth, and father of the Titans and Cyclopes. It is said that this great old god hated his children and because some of them aspired to the throne he confined them in Tartarus. From this dread abode, under the leadership of Cronos, they finally made a successful escape, and having organized a powerful attack, drove Uranus from the throne of Olympus.

Sound—Since Uranus was unknown to the ancients he plays no part in the fancied Music of the Spheres, but nevertheless, he has always been a constant, though unheard, member of the starry symphony.

Colour—Uranus is barely visible to the unaided eye, but in a large telescope it shines with a greenish tint and has darker bands above and below the equator, similar to Jupiter.

Markings—Even in a large telescope it appears as a very small disc and only under the best seeing conditions can the belts be discerned. No markings have been found of sufficient permanence to determine the rotation period exactly.

Stellar Magnitude—It is of the sixth magnitude and varies only slightly with its orbital position on account of its small eccentricity and its great distance from the sun. Curiously enough, however, it varies perceptibly during its rotation on account of some irregularity of its surface.

Angular Diameter—3.8 sec. of arc. This also varies but little because the addition or subtraction of the diameter of the earth's

orbit in a distance so great does not alter the angle enough to make any appreciable difference.

Linear Diameter—30,800 miles. This is the mean actual diameter and is about four times that of the earth or 1/29 that of the sun. The equatorial diameter is about 30,900 miles and the circumference about 96,800 miles.

Area of Surface—2,955,000,000 square miles, about 15 times that of the earth or 1/800 of the sun.

Volume—15,000,000,000,000 cubic miles, about 60 times that of the earth or 1/22,000 of the sun.

Mass—14.6 times that of the earth or 1/22,800 of the sun.

Density—1.22 of water or .22 of earth. This indicates a condition quite similar to that of Jupiter.

Surface Gravity—.9 of the earth. An object weighing 100 pounds here would weigh about 90 pounds there.

Rotation Period—This has not yet been exactly determined although Lowell claimed it rotates in 10 hrs. 45 min. while Slipher made it 5 min. longer. This would be about 5 hrs. daylight and 5 hrs. darkness each day, similar to Jupiter and Saturn, and there would be the enormous number of about 73,800 days in a Uranian year. The direction of rotation is apparently backward or from east to west.

Equatorial Velocity—This is difficult to determine on account of the vague markings, but the above period would indicate a speed of about 2.5 miles a sec., or 9,000 miles an hour—nearly 9 times as fast as the earth.

Polar Flattening—.09. This is a little greater than that of Jupiter and a little less than that of Saturn, and would indicate a rather large equatorial bulge for the size of the planet.

Distance from Sun—Its mean distance is about 1,782,000,000 miles or 19.19 astronomical units. At aphelion its distance is about seventy millions of miles more than at perihelion.

Revolution (Sidereal Period)—84.02 of our years or about 30,680 days, about 7 times as long as Jupiter; so it advances only about 4 degs. each year. We must remember that these 84 years are but 1 year to the Uranians if such there be.

Revolution (Synodic Period)—369 days. That is the time

between conjunctions or oppositions as seen from the earth, and these, of course, are repeated often as we shall see later.

Orbital Velocity—4 miles a sec., 14,400 miles an hour, 345,600 miles a day. Its mean daily motion as seen from the sun is 42 sec. of arc.

Perturbations—Uranus suffers occasional perturbations because of the attraction of Neptune whenever they approach each other in their orbits. This was very carefully estimated by Adams and Leverrier and led to the discovery of the latter planet within a degree of the calculated position.

Arc of Retrograde—4 degrees of arc. This is about the same as its annual advance, but it does not mean that the planet is losing as much as it gains for the retrograde motion is only apparent to us.

Eccentricity of Orbit—.047. This is so small that it does not alter the planet's distance or its speed enough for ordinary observation. As we have already noted, the difference between perihelion and aphelion distances is only 70 millions of miles in an orbital diameter spanning the enormous distance of over 3.5 billions of miles.

Solar Radiation—.003 of our supply. The amount of light and heat received is necessarily very small because of the great distance.

Albedo—.63. This is about the same as Jupiter, but on account of its great distance and its small diameter its ratio of brilliancy is difficult to observe and determine.

Atmosphere—The high albedo indicates a cloud-laden atmosphere similar to the other brilliant planets and possessing a strange element which produces the beautiful greenish tint that we observe.

Temperature—Like the other major planets it would seem that Uranus must still be in gaseous condition and with a dense atmosphere there will be a considerable surface temperature but its degree is not yet known.

Longitude of Perihelion—169° 24′. Uranus was last at perihelion in 1883 and will return to it again in 1967.

Inclination of Equator to Orbit—Some say 82°, but others state it as 98° and this seems to explain better the backward motion of the system. Being only 8° from perpendicular to the orbit there would be very strange seasons if we may think of seasons at all.

Inclination of Orbit to Ecliptic—Only 48′. This is least of

all and almost in the same plane as the earth. A combination of great and small inclinations that would produce, on one polar hemisphere, a very cold summer of 21 years duration with the sun apparently revolving around the pole without setting; while the other polar hemisphere, turned from the sun, endures an exceedingly frigid winter, totally dark except for the oft-repeated but faint illuminaton of the hurrying satellites. Then when the planet reaches the other side of the sun, the conditions are reversed for a similar period, while between the two the equatorial regions receive the direct rays of the distant sun for equal periods.

Oppositions—These occur every year, the most recent having occurred on September 25, 1927 just three days latter than Jupiter.

Conjunctions—These occur with the sun, the moon and the other planets and may be observed as indicated in the *Observer's Handbook*.

Satellites—Another peculiarity of this interesting system is a retinue of four tiny moons that revolve, like their primary, in a backward direction from east to west, or more correctly, from north-north-east to south-south-west and almost in the same plane as the planet's equator. This inclination was challenged by Barnard who felt sure that he found an angle of about 28° between the plane of the orbit of the satellites and the plane of the planet's equator. These four moons were discovered by two English astronomers, Sir Wm. Herschel and Wm. Lassell. In 1787, Herschel, who had previously discovered Uranus, found the two larger and outer ones: Oberon, with an estimated diameter of about 800 miles, a period of revolution of 13 days 11 hrs., and a distance of some 365,000 miles; and Titania, with a diameter of 1,000 miles, a period of 8 days 17 hrs., and a distance of 273,000 miles. In 1851 Lassell discovered the two smaller and nearer ones: Umbriel, with a diameter of about 400 miles, a period of 4 days 3.5 hrs., and a distance of 167,000 miles; and Ariel, with a diameter of about 500 miles, a period of 2 days 12.5 hrs., and a distance of 120,000 miles.

Life—In this strange system there is no evidence of life of any kind as we know it, and doubtless many years will elapse before we can obtain further reliable information.

Lambeth, Ontario.

REVIEW OF PUBLICATIONS

Memoirs of the National Academy of Sciences. Volume XXII, Washington, D.C., 1927.

The Memoirs of the National Academy of Sciences, Volume XXII, First Memoir, contains the result of work carried on at the Leander McCormick Observatory by S. A. Mitchell, C. P. Olivier, H. L. Alden and others. The first part contains the parallaxes of four hundred and forty stars. In all, the observatory has now made parallax measures of 700 stars, a truly monumental work. Bessel determined the first stellar distance less than a century ago, but even as late as 1910, the number of accurate parallaxes was very small. Kapteyn, in a list published at that time from Groningen, included about 300. The accurate determination of trigonometric parallaxes in large numbers starts with the perfection of the photographic method by Russell, Schlesinger and others. The distances of about 2500 separate stars have now been measured. The observatories which have contributed largely to this work are Groningen, Greenwich, Cape, Yerkes, Sproul, Mt. Wilson and McCormick. The reader will appreciate the large part taken by the Leander McCormick Observatory. The probable error, 0″.0096, shows that the high standard of accuracy of the earlier list has been maintained. We may confidently look forward to the day when we shall have the distances of all the naked eye stars.

In addition to the work on parallaxes, the volume contains the results of other work of the observatory. In Part 2, there is a direct determination of the distance of the Pleiades, by Alden. The value +0″.009 is obtained as the most probable value of the absolute parallax. A combination of the results of the Sproul Observatory with those made at the Leander McCormick gives an absolute parallax +0″.011.

Part 3 gives an investigation into the solar motion and into the systematic errors existing in the declinations of Boss' Preliminary General Catalogue. The result of the work is to confirm what is now generally believed, that the declination of the stars are subject to systematic errors. It is quite probable that the existence of errors in proper motions in declination may explain the discordant values obtained for the declination of the Solar Apex.

Part 4 contains the result of photographic measures of double stars. The values obtained are of high order of accuracy, probably exceeding those made by the micrometer method.

R.K.Y.

Publications of the Yerkes Observatory, Volume V, Part 1. By George VanBiesbroeck. University of Chicago Press, 1927.

Volume 5, Part 1, of the Publications of the Yerkes Observatory contains a re-measurement of the double stars discovered by Hussey. The total number of stars measured is 1342. The interval separating the discovery observations from the re-measurements is about twenty years. Of the 1342 stars, 23 show definite orbital motion, 216 show common proper motion and 230, while not showing a curved path, still show enough change to class them as binaries. Of the remainder, 820 are relatively fixed, 14 are definitely optical doubles and 39 seem to indicate some change of unknown character. The measures are not only valuable in themselves, but will serve as a guide to direct future observations of these stars. A meritorious feature of the work is the completeness with which the Hussey stars have been re-measured, there being only five stars missed and these unavoidably.

The discussion contains a comparison of the personal equation errors between Hussey and VanBiesbroeck and they are satisfactorily small. In cases where other observers have measured the same stars, the measures are recorded so that the volume serves as a reference to the observations of Hussey's stars subsequent to their discovery.

R.K.Y.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Officers for Toronto Centre

At the meeting of the Society at Toronto on November 1, Messrs. A. F. Hunter, J. R. Collins and A. R. Hassard were appointed a Board to conduct the ordinary meetings until the end of the year.

A Bright Meteor

Mr. A. S. Millard, of Hawkestone, Simcoe Co., Ont., sends the following account of a meteor seen by him:—"On October 26, 1927, at 8.45 p.m., I saw a high-bred meteor, or shooting star, south and a little west, slightly to the west of the bright evening star and appearing at the same height as the star. It was travelling quite slowly, became incandescent and at the end broke into three, or so, flaming pieces and disappeared half-way between the star and the horizon. It broke very like a good rocket but it gave the impression of being a long way up for a rocket and also of being much closer at the finish than the usual shooting star."

It would be interesting to receive other reports of this meteor.

Meteor Shakes the Ground

In a Toronto evening paper for November 15 appeared a despatch from Niagara Falls which stated that earthquake tremors which were said to have been felt in that vicinity on Saturday night, the 12th, were attributed to a meteor. It is reported that several saw the phenomenon, but the description given does not inspire confidence in the accuracy of the observation. The body was not found and so it is thought to have fallen in the Niagara River between Niagara Falls and Buffalo. It is unfortunate that these bodies so often escape. An account of one which actually fell to earth and was recovered is given on another page of this issue.

Nebulium

Some progress towards solving the problem of the nature of "nebulium," the hypothetical element in the gaseous nebulae is reported by *Science Service*, as follows:—

Nebulium, the strange "element" that has been supposed to exist in such bodies as the great cloud of glowing gas in the star group of Orion known as the Great Nebula, seems to be nothing but oxygen and nitrogen. This is the opinion of I. S. Bowen, of the Norman Bridge Laboratory of Physics.

Following the discovery of helium, first as a strange line in the spectrum of the sun, and then as an actual element on the earth, a mysterious group of lines was found in the spectrum of some of the nebulae. As most of the spectral lines are known to be due to certain elements, it was thought that the strange lines, of which one was green, might be due to an element as yet undiscovered.

Dr. Bowen's studies now indicate, however, that these lines are due at least partly to oxygen and nitrogen, of which the air is chiefly composed, but in what is termed the "metastable state." While in the laboratory atoms of certain gases can be induced to enter this state, they ordinarily return to the normal condition without giving off light, by bumping into another atom or the walls of the containing tube. In the nebula, however, the pressure is very low, probably much lower than the lowest terrestrial vaccum, which means that the atoms are not so crowded. They are therefore less apt to bump into each other, and the walls of the tube are absent. The result is that the atoms remain longer in the metastable state and finally return to normal condition spontaneously. According to Dr. Bowen's calculations, if this happened, light would be given off of the same wave-lengths as the mysterious nebulium lines.

Dr. Bowen reported his conclusions recently to *Nature*. In a later issue, Professor A. Fowler, a leading English authority on the subject, states that the evidence, on the whole, "appears to be in favor of Mr. Bowen's suggestions." He also suggests that one of the lines, in the part of the spectrum just beyond the red end, should be accompanied by a fainter line, on the side towards the visible spectrum. If astronomers can discover this in the spectrum photographs of the nebulae, it would be strong evidence in fovor of Dr. Bowen's view.

An Auroral Display 1000 Kilometers High

Professor Carl Störmer, of Oslo, Norway, continuing the work of determining the heights of the aurora, which he began over fifteen years ago, reports on a very high display observed on September 8, 1926. It was of the curtain variety and was of a violet gray

colour. Photographs of it were taken from Bygdo and Oscarborg, 26 km. apart and near Oslo, and measurements showed that it was situated in a layer from 300 to 500 kms. above the earth. The curtain was later transformed into a feeble diffuse mass, sharply bounded to the south and of a violet mauve colour. From a photograph it was calculated that this aurora probably reached the immense height of more than 1000 km.

The diffuse aurorae of a red violet or similar colour which Professor Störmer has photographed since 1911 all were very high in the atmosphere and seemed to emit ultra-violet light.

As is well known, Störmer found that auroral curtains and arcs with ray structure are usually in the layer from 80 to 120 kms. above the ground but the display described above seems to be almost of a different class.

The present writer would congratulate Professor Störmer on his admirable work and on his persistence in it.

The Lunar Eclipse of June 15, 1927

This eclipse has given rise to considerable discussion. In the Nautical Almanac it is said to be total, but various observers have contended that it was not total. On page 27 of the *Handbook* for 1927 is a diagram of the path of the moon through the shadow, and it is seen that at greatest eclipse the moon was just within the shadow.

The present writer has received the publications of the New Zealand Astronomical Society for the past year, and they contain much interesting matter. In the "Notes" for July, 1927, is a discussion of this eclipse by Mr. E. G. Hogg, which is quoted herewith:—

"The interest of a lunar eclipse mainly centres on the colour assumed by the moon's disc during the period of totality, and in this respect the recent eclipse was one of the most remarkable which has occurred for many years.

In a total eclipse the moon may be immersed in the earth's umbra for as long as 1 hour 50 min., but in the eclipse of June 15th the period of totality lasted only 22 minutes. From a note in a recent issue of "Nature" it appears that on the occasion of this eclipse the radius of the geometrical umbra was 40.8 minutes of arc and that at mid-eclipse the distance of the outer limb of the moon from mid-shadow was 40.7 minutes of arc, *i.e.*, the moon only just succeeded in getting totally eclipsed. As a consequence of the proximity of

the moon's limb to the edge of the umbra the lunar disc was so highly illuminated as to raise doubts whether the eclipse had really been total.

We may here recall that in the lunar eclipse of November 4th, 1892, when the moon was really further immersed in the umbra than on the recent occasion, Gale, at Sydney, reported the limb so bright as to give the impression that the eclipse was not total: Russell, Government Astronomer for New South Wales, said definitely that it was not total, and Doberck, at Hong-Kong, remarked on the brilliancy of the immersed limb. It is not to be wondered at then if, having regard to the conditions obtaining during the recent eclipse, observers may have had their doubts as to whether is was total. The colour of the lunar disc was generally reported as of a burnished coppery hue; one observer described it as umber, and one remarked on the apparent movement of the brighter part of the shadow round the moon's edge during the total stage.

During the progress of a lunar eclipse the rays of the sun, entering the earth's atmosphere almost horizontally, undergo so much refraction that a considerable quantity of solar light may fall on the moon's surface and be reflected thence to the earth. The colour of the immersed lunar disc depends on the quantity and quality of this light; the moisture in the earth's atmosphere absorbs the shorter light-waves and transmits only the long ones, thus giving the moon the red glow it often presents during an eclipse. If very heavy clouds exist in the atmosphere little or no light may penetrate it, and in that case the moon will have a dull grey colour. Hence the aspect of the eclipsed moon varies with the state of that region of the atmosphere through which the solar light is passing. In the eclipse of March 19th, 1848, the moon was seen so clearly that many persons doubted the reality of the eclipse, while with regard to the eclipse of May 18th, 1761, Wargentin writes: 'Eleven minutes after the beginning of the total phase, the moon's body had disappeared so completely that not the slightest trace of any portion of the lunar disc could be discerned either with the naked eye or with a telescope, although the sky was clear and the stars in the vicinity of the moon were distinctly visible in a telescope.'

We may close this note on the eclipse by stating that the earliest recorded observation of a lunar eclipse was made in the 27th year of the era of Nabonassar, on the 29th day of the Egyptian month Thoth, which corresponds in our reckoning to March 19th, 720 B.C.: it appears to have been total at Babylon.

The eclipse of the moon which happened on March 13th, 4 B.C., has been used by some chronologists to determine the date of the birth of the Founder of Christianity. This event preceded by a few weeks the death of Herod, and, according to Josephus, that occurred soon after a lunar eclipse which has been identified as the one which took place on the above date. If this be correct, it would bring the Nativity into the autumn or winter of the year 5 B.C."

C. A. C.

MEETINGS OF THE SOCIETY

At Montreal

A meeting was held on April 27, 1927, in the Macdonald Physics Building, Col. W. E. Lyman in the chair. New members were elected as follows:—

Mrs. William Caldwell.
Mr. A. R. Martin.
Mr. Julian R. Sorsbie.
Dr. W. D. Lighthall.
Mr. P. J. Sheppard.
Mlle. E. Gendron.
Mr. Gustave Monat.

The President welcomed the Director of the Dominion Observatory, Ottawa, Mr. R. Meldrum Stewart, who delivered a lecture entitled "Sounding the Universe."

Various methods of finding stellar distances were outlined

(1) Fundamental survey method applicable to nearer stars.
(2) By means of solar motion, applicable to groups.
(3) From angular separation and period of binaries, assuming an average mass.
(4) Spectroscopic parallaxes (1916 Adams & Kohlschutter).
(5) From Cepheid Period-Luminosity Law.

Some very beautiful slides were shown, especially of the spiral nebulae whose nature and distance were discussed as well as the probable configuration and dimensions of the galaxy of stars to which our sun belongs.

A very hearty vote of thanks was tendered the lecturer by Mr. Justice E. E. Howard.

Mr. Armand invited those present who were not members to join the Society, after which the meeting adjourned.

The first meeting for the 1927-28 season was held in the Macdonald Physics Building on November 3, 1927. The President, Col. W. E. Lyman, in the chair. New members were elected as follows:—

Miss J. Smellie,
Mr. C. A. Peachy,
Mr. L. R. McDonald,
Mr. Jas. A. Wright,
Rev. H. Britten.

Mr. Luttrell moved a resolution conveying the thanks of the Society to the Director of the Macdonald Physics Building for so generously granting the use of the Lecture Theatre for the Society's Meetings. Dr. L. V. King

moved a resolution of sympathy with the family of the Rev. W. T. B. Crombie whose death is felt to be a great loss by his many friends.

The Secretary's and Treasurer's Reports for the year were read.

In connection with the election of officers, it was strongly urged by Mr. Armand and Mr. Wright that Dr. A. S. Eve, F.R.S., be nominated for presidency. Dr. Eve maintained, however, that the office should be held by a citizen not directly connected with McGill University. It was moved by Mr. Lutrell, seconded by Professor Kelly that the election of President be left over until the December meeting. The other elections resulted as follows:

Honorary President—Mgr. C. P. Choquette.
President— ———
1*st Vice-President*—Mr. H. E. S. Asbury.
2*nd Vice-President*—Mr. Justice E. E. Howard.
Treasurer—Prof. A. J. Kelly.
Secretary—Dr. A. V. Douglas.
Council—Dr. A. S. Eve,
Col. W. E. Lyman,
Mr. J. T. Armand,
Mr. J. Lutrell,
Mr. G. Sample,
Miss J. Fleet,
Dr. J. B. McConnell,
Mr. P. A. Waterman.

The lecture of the evening was given by the Secretary on the subject "Stars and Atoms."

Reference was made to Professor A. S. Eddington's recent book, "Stars and Atoms" (Clarendon Press, Oxford 1927) and several typical paragraphs were read. Slides were shown illustrating the surface features of the sun, the electron orbits of simple and complex atoms, the ionization produced by electronic and atomic collisions and the passage of X-rays through a gas, the spectra of some stars of special interest and the instruments with which these spectra were taken.

The most massive stars known to exist were referred to, *viz.*, Plaskett's giant binary stars in Monoceros and Struve's giant quadruple system in Canis Major.

The confirmation of Eddington's theoretical researches which have been furnished by Algol, Sirius and Betelgeuse were outlined and in conclusion brief reference was made to the possible sources of energy within a star.

The thanks of the Society were expressed to the lecturer by Dr. Eve after which the meeting adjourned.

A. VIBERT DOUGLAS,
Secretary.

AT TORONTO

April 12, 1927.—The regular fortnightly meeting was held in the Physics Building of the University of Toronto, on Tuesday, April 12, 1927, at 8 p.m., Mr. A. F. Hunter, president of the Society, in the Chair.

Professor Gilchrist addressed the Society on "Measurements of Stellar and Molecular Magnitudes."

A brief account was given of the lower and upper limits of lengths, areas, volumes and masses for which methods of measurements have been devised in recent years.

The radius of a proton, or an electron, was contrasted with the radius of Betelgeuse; and the wave-length of gamma rays with that of some electric waves used in wireless signalling.

In particular, methods of measurements of these magnitudes which make use of the phenomena of interference of light waves were described in which, in some cases the interference fringes were used directly in the measurement of the thickness of soap films or in other cases by a determination of the visibility of the fringes, *e.g.*, in the measurement of the diameter of Betelgeuse.

April, 26.—The regular fortnightly meeting was held on the 26th of April, 1927. Mr. A. F. Hunter in the chair.

Mr. Alfred Lowe, of Lacolle, Quebec, was elected a member of the Society.

Prof. R. K. Young was the lecturer of the evening; his subject being, "The making of a Reflecting Telescope."

Prof. Young has had a great deal of experience and success in the actual work of grinding mirrors. He first explained the difference between a refracting and a reflecting telescope, showing photographs of the large instruments of both kinds in the various observatories of this continent. He also explained the mountings with the intricate mechanism for operating them. The largest reflecting telescope is to be found in the Carnegie Solar Observatory being 100 inches in diameter. The glass weighs over two tons.

During the course of his talk the lecturer demonstrated the method of grinding and showed how he made the tools used by himself.

The lecture was exceedingly interesting and practical. Discussion followed, during which Mr. J. R. Collins remarked that some telescope makers used speculum metal, and stated that he had a piece in his possession 60 years old, the surface was still in good order.

Prof. Chant mentioned that pyrex glass was much used now, it was valuable on account of its smaller coefficient of expansion by heat.

Mr. Hunter voiced the thanks of the meeting to the lecturer for the very practical and instructive address.

October 18.—The opening meeting for the season 1927-8 was held in the Physics Building of the University. The President, Mr. A. F. Hunter, occupied the chair.

On account of the rather lengthy programme, Mr. Hunter thought best to dispense with the reading of the minutes of last meeting. The President then informed the meeting that the General Council of the Society had decided to form a distinct Toronto Centre. This called for the election of officers, and the suggestion from the chair was made to nominate, if the meeting so desired, members for the following offices:—President, Vice-President, Secretary-Treasurer, and three members to form a Council.

Considerable discussion followed, in which Dr. Marsh, Mr. A. F. Miller, Mr. Collins, Prof. Chant, and others took part. Mr. Miller, to whom the matter came as a surprise, wished to know why such a move was necessary, he thought the term "Centre" a misnomer, and was opposed definitely to any change in our organization. He cited the British Society's Procedure—with one office and one meeting, in London.

Prof. Chant explained that the thought was to regularize our proceedings and programmes. No change was contemplated in the functioning of the General Society and Council; the smaller group to take care of the local work only, as at the other centres.

It was finally decided, on motion by Mr. Miller, seconded by Mr. Collins that the matter be deferred until our next meeting for further discussion and action.

The following were elected members of the Society:—

A. R. Dunlop, Box 745, New Westminster, B.C.
Walter Burt, 56 Celebration St., St. John, N.B.
I. H. Friend, 639 Migeon Avenue, Torrington, Connecticut.
George W. Gray, Sparkhill, New York, U.S.A.
Pierre Augers, 485 Wilson Ave., Montreal.
E. P. Burns, 14 Fairview Blvd., Toronto.
T. Harold Brown, 2108 Danforth Ave., Toronto.
Robert Gasche, Buffalo, N.Y.

The Librarian's report was presented. Since the last meeting the Society had received 250 periodicals.

Under reports of Observations, Mr. Hunter spoke of some telescopic photographs taken by Dr. Marsh during the summer. A beautiful series of slides of these photos was cast on the screen. The slides comprised views of the phases of the moon together with excellent pictures of Jupiter and Mars.

The feature of the evening was the President's address. The title of his paper was "Some advances during the past year in Astronomy and its allied subjects." Mr. Hunter reviewed the astronomical field drawing attention to the advances and discoveries of importance during the year, besides being

most informative, even the technical passages were given in an interesting fashion, the paper appears in this number of the *Journal.*

Afterwards, Mr. W. A. Connolly shewd a series of colour photographs taken of sunrises and sunsets. Prof. Barnes, of McGill University, has been experimenting in colour photography, assisted by Connolly; they have succeeded in reproducing the wonderful colour effects in the sky of sunrise. The brilliant pictures on the screen were the results of a year's arduous work in the region of the St. Lawrence river, near Morrisburg.

Prof. McTaggart, of the Physics Department of the University, expressed his appreciation of the fine work, and beauty of the pictures shown.

A. KENNEDY,
Recorder.

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